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Productivity growth and biased technical change in French higher education

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ABSTRACT

This paper analyses the nature of technical change in the French labour market. Data Envelopment Analysis (DEA) is adopted to investigate productivity change in a sample of higher education leavers over the period 1999 and 2004. In a first step, the Luenberger Productivity Indicator (LPI) is used to estimate and to decompose productivity change. Following LPI, a better productivity is found for the workers in Paris and the well-qualified occupations in France. In analysing the nature of the technical change by the concept of parallel neutrality, technical progress seems to have influenced all professions. In particular, biased inputs of human capital component benefit more for the well qualified professions with an upper increase of the efficiency scores for executives and teachers. Furthermore, some evidences show the key role of "learning by doing" in the worker's adaptation to technical change. Policy implications are then derived from our results.

1. Introduction

Assessment of education efficiency and the optimal investment of schooling have been studied since long time (e.g. Mincer, 1958). Following human capital theory, there is a lack of investments in education (Becker, 1962; Schultz, 1961). Some frameworks however appear in the beginning of the seventies which counterbalance this idea. In particular, the overinvestment idea in education was firstly investigated by Freeman (1971, 1976) and Dore (1976). Freeman found that education returns have significantly decreased in the United States. He assigned these diminishing returns to an excess of graduate offer. The results called into question the belief that college degrees mirror a profitable investment and a virtual guarantee of economic success. Freeman's work has then catalysed a large literature on overeducation topic.[1] Meanwhile, several papers have showed significant overeducation rates in several developed countries (Sloane, 2003).

Today, the overeducation concept can be defined as follows: a worker is considered as overeducated if his/her educational level exceeds that required for a particular job.[2] Therefore, the overeducation literature asks again the assessment of education efficiency in taking surplus schooling into account. In other words, this literature suggests a diminishing of education efficiency due to the mismatch between offer and demand of skills. In this topic, Guironnet and Peypoch (2007) have proposed a new measure of overeducation[3], in using efficiency scores of human capital components. This previous paper has measured overeducation as the difference between potential income — determined by the frontier of the production boundary — and real income.[4] Several frameworks have used the frontier approach to explain the gap between the current and potential wage. For example, Polachek and Robst (1998)[5] have considered the residual (determined by a stochastic production frontier) between potential and current wages as a lack of information about the correspondent wages and the educational level for the job. In this paper, we choose a different specification of our frontier approach in order to have a more general interpretation in terms of overeducation: a part of this phenomenon is probably due to a lack of information. One benefit of our measure is to capture the technical change which is measured upon the durable professional insertion of graduates from higher education. For this purpose, this framework studies the durable insertion of graduates of higher education.

In the present paper, the aim is to extend the extant literature by investigating whether the innovation process influences the skill demand. For example, if the wage downgrading measure quantifies technical change for all professions, this framework proposes to study the effects of innovations upon each occupation: is there a stronger influence of technical progress for some professions? Which type of bias: formal or informal education "saving"?

To answer to these questions, the first section presents the theoretical model to apply our measure and the decomposition of

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[1] See McGuiness (2006) or Hartog (2000) for a survey.
[2] Conversely, an individual can be considered as undereducated if his educational level falls below that required by the job.

[3] See this paper for a brief presentation of overeducation measurements.
[4] This measurement method has been previously investigated by Jensen (2003).
[5] The reader can also look Gaynor and Polachek (1994) and Polachek and Yoon (1987).

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technical progress. Second section presents the data and the statistical insights. Third section presents and comments the results before to conclude.

2. Methodology

This section, first, presents the theoretical model for productivity measurement and, second, the decomposition of productivity change to assess the nature of technological change.

2.1. The Luenberger productivity indicator

Represent inputs by $x \in \mathbb{R}^n_+$ and outputs by $y \in \mathbb{R}^p_+$. The production set T_t is the set of all the input–output vectors $(x,y) \in \mathbb{R}^{n+p}_+$ such that

$$T_t = \left\{(x,y) \in \mathbb{R}^{n+p}_+ : x \text{ can produce } y \text{ at } t\right\}. \tag{1}$$

Let $L_t : \mathbb{R}^p_+ \to 2^{\mathbb{R}^n_+}$ denote the input correspondence that maps all $y \in \mathbb{R}^p_+$ to input sets capable of producing them

$$L_t(y) = \{x \in \mathbb{R}^n_+ : (x,y) \in T_t\}. \tag{2}$$

The output correspondence $P_t : \mathbb{R}^n_+ \to 2^{\mathbb{R}^p_+}$ maps all $x \in \mathbb{R}^n_+$ into sets of outputs that can be produced by those inputs:

$$P_t(x) = \{y \in \mathbb{R}^p_+ : (x,y) \in T_t\}. \tag{3}$$

We have

$$(x,y) \in T_t \iff x \in L_t(y) \iff y \in P_t(x). \tag{4}$$

For all vectors z,w in $\mathbb{R}^m$ we denote $z \le w$ if $z_l \le w_l$ for all $l = 1 \cdots m$
We impose standard properties on the technology:

T1. $(0,0) \in T_t$, $(0,y) \in T_t \Rightarrow y = 0$ i.e., no fixed cost and no wages without skills;

T2. the set $A(x) = \{(u,y) \in T_t : u \le x\}$ of dominating observations is bounded $\forall x \in \mathbb{R}^n_+$, i.e., infinite outputs cannot be obtained from a finite input vector;

T3. T_t is closed;

T4. For all $(x,y) \in T_t$, and all $(u,v) \in \mathbb{R}^{n+p}_+$, we have $(x,-y) \le (u,-v) \Rightarrow (u,v) \in T_t$ (free disposability of inputs and outputs);

T5. T_t is convex.
Assumptions T1–T5 imply that for all $(x,y) \in T$, the subsets $L_t(y)$ and $P_t(x)$ are closed, convex and satisfy free disposability.
The directional distance function $D_t : \mathbb{R}^{n+p}_+ \times \mathbb{R}^{n+p}_+ \to \mathbb{R} \cup \{-\infty\} \cup \{+\infty\}$ is defined by:

$$D_t(x,y;h,k) = \begin{cases} \sup\{\delta : (x-\delta h, y+\delta k) \in T_t\} & \text{if } (x-\delta h, y+\delta k) \in T_t \text{ for some } \delta \in \mathbb{R} \\ -\infty & \text{otherwise} \end{cases}$$

The definition implies $D_t(x,y;0) = +\infty$. However, the direction $g = (h,k)$ is fixed, and hence we suppose that $g \neq 0$. Detailed properties of the directional distance function can be found in Chambers et al. (1996).
The directional distance function is a function representation of the technology, namely

$$(x,y) \in T_t \Leftrightarrow D_t(x,y;g) \ge 0.$$

$D_t(\cdot\,;g)$ is also concave and continuous on the interior of $\mathbb{R}^{n+p}_+$.
If $h \neq 0$ and $k \neq 0$ then:

$$D_t(x,y;h,0) \ge 0 \iff x \in L_t(y) \quad \text{and} \quad D_t(x,y;0,k) \ge 0 \iff y \in P_t(x). \tag{5}$$

Following Briec and Kerstens (2009a, 2009b), to avoid the problem of infeasibility, a good way is to consider the dual formulation of the directional distance function. To do this, we first introduce the profit function $\Pi_t : \mathbb{R}^{n+p}_+ \to \mathbb{R} \cup \infty$:

$$\Pi_t(w,p) = \sup_{(x,y)} \{p.y - w.x : (x,y) \in T_t)\} \tag{6}$$

The function $\bar{D}_t : \mathbb{R}^{n+p}_+ \times (-\mathbb{R}^n_+) \times \mathbb{R}^p_+ \to \mathbb{R} \cup \{-\infty\}$ is then defined by:

$$\bar{D}_t(x,y;h,k) = \inf_{(w,p) \ge 0} \{\Pi_t(w,p) - p.y_t + w.x_t : p.k - w.h = 1\} \tag{7}$$

In such a case, we have for all $g \in (-\mathbb{R}^n_{++}) \times \mathbb{R}^p_{++}$, then $\bar{D}_{\hat{T}}(z;g) = \min_{(w,p) \ge 0}\{\widehat{\Pi}(w,p) - p.y_t + w.x_t : p.k - w.h = 1\}$ where $\widehat{\Pi}$ is relative to the nonparametric technology $\hat{T}$ (Briec and Kerstens, 2009a, 2009b). It follows that:

$$\bar{D}_{\hat{T}}(z;g) = \min_{(w,p) \ge 0} \{\max_{j \in J}\{p.(y^j - y_t) - w.(x^j - x_t)\} : p.k - w.h = 1\},$$

where a set $\{(x^1,y^1), \dots, (x^J,y^J)\}$ of J observed activities is such that $j \in J$. The linear program that computes the values of each directional distance function is:

$$\begin{aligned} \bar{D}_{\hat{T}}(z;g) = \min \delta \\ & \delta \ge p.(y^j - y_t) - w.(x^j - x_t) j \in J \\ & p.k - w.h = 1 \\ & p \ge 0, w \ge 0, \delta \ge 0. \end{aligned} \tag{8}$$

Following Chambers (1996) one can introduce a Luenberger productivity indicator to measure the productivity changes between two time periods. This Luenberger productivity indicator is defined by

$$L(x_t,y_t,x_{t+1},y_{t+1};g) = \frac{1}{2}[\, D_{t+1}(x_t,y_t;g) - D_{t+1}(x_{t+1},y_{t+1};g) + D_t(x_t,y_t;g) - D_t(x_{t+1},y_{t+1};g)\,]. \tag{9}$$

Positive growth (decline) is indicated by positive (negative) value. The Luenberger productivity indicator is additively decomposed as follows

$$\begin{aligned} L(x_t,y_t,x_{t+1},y_{t+1};g) = {} & [\, D_t(x_t,y_t;g) - D_{t+1}(x_{t+1},y_{t+1};g)\,] \\ & + \frac{1}{2}\Big[\big(D_{t+1}(x_{t+1},y_{t+1};g) - D_t(x_{t+1},y_{t+1};g)\big) \\ & + \big(D_{t+1}(x_t,y_t;g) - D_t(x_t,y_t;g)\big)\Big], \end{aligned} \tag{10}$$

where the first term (inside the first brackets) measures efficiency change between periods t and $t+1$. Hence, we denote:

$$EFFCH = D_t(x_t,y_t;g) - D_{t+1}(x_{t+1},y_{t+1};g). \tag{11}$$

The second term (inside the second brackets) captures the technical change component and represents the shift of technology between periods t and $t+1$. Thus, technical change is denoted as:

$$TECH = \frac{1}{2}\Big[\big(D_{t+1}(x_{t+1},y_{t+1};g) - D_t(x_{t+1},y_{t+1},g)\big) + \big(D_{t+1}(x_t,y_t,g) - D_t(x_t,y_t,g)\big)\Big]. \tag{12}$$

The decomposition of the productivity change into technical efficiency change and technological change was proposed in Chambers